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(54) An artificial foot for testing footwear and/or socks.

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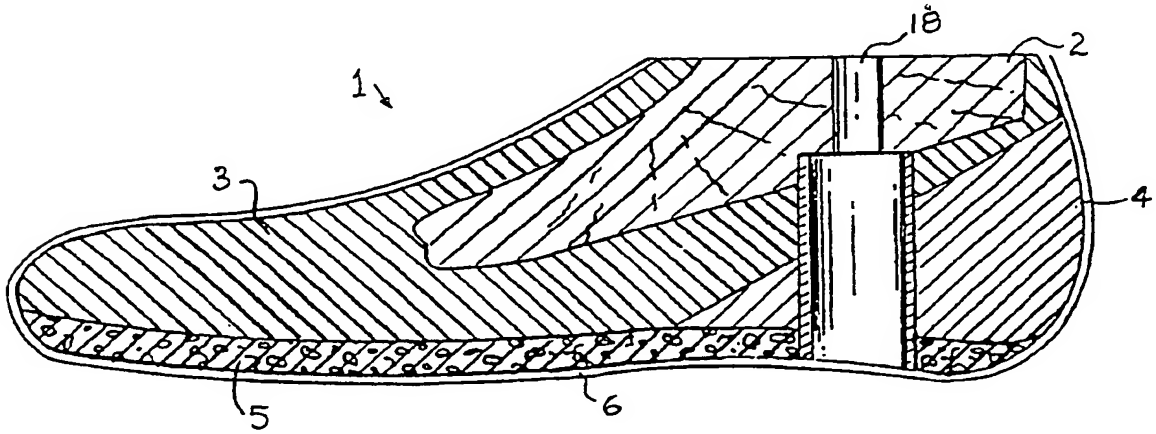
FIG 1



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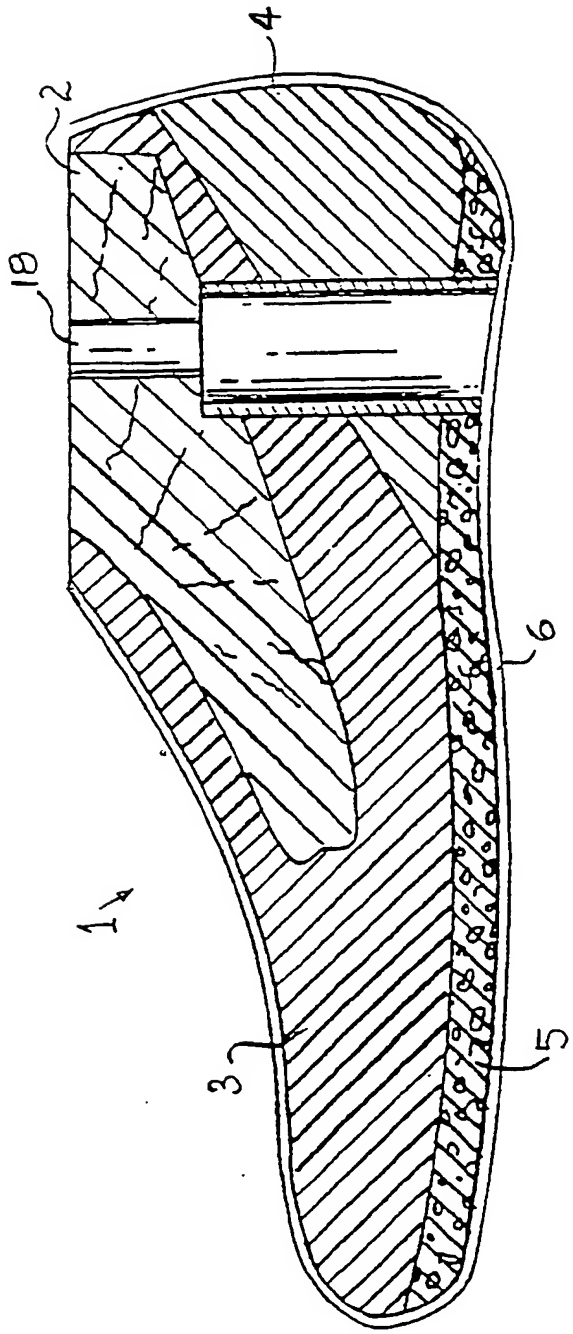

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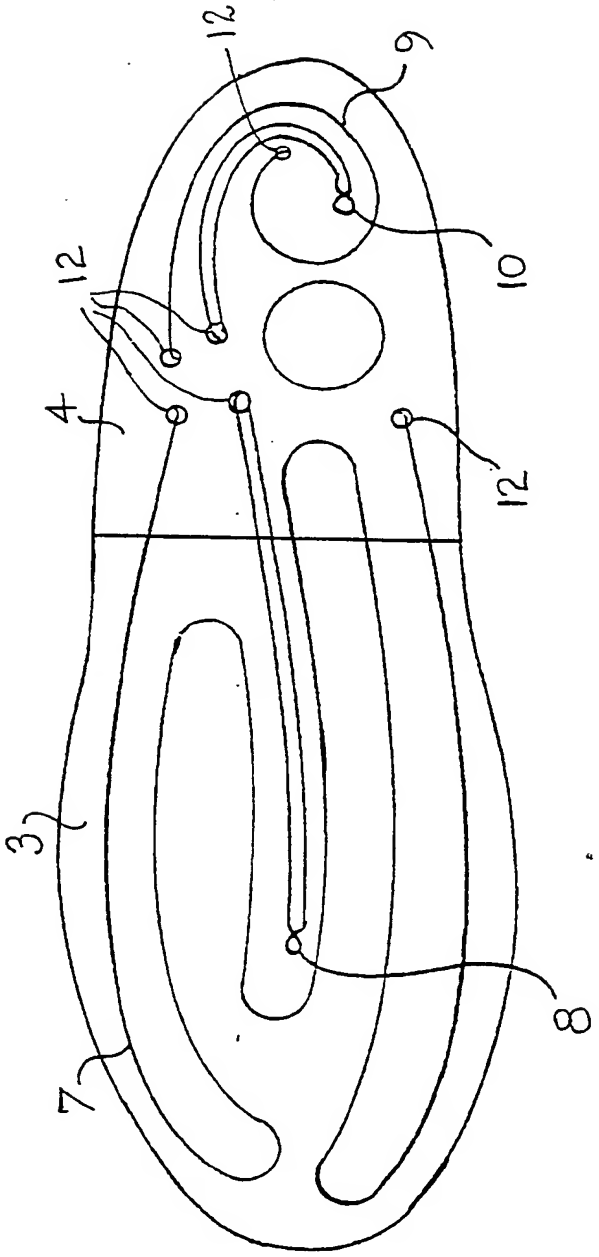
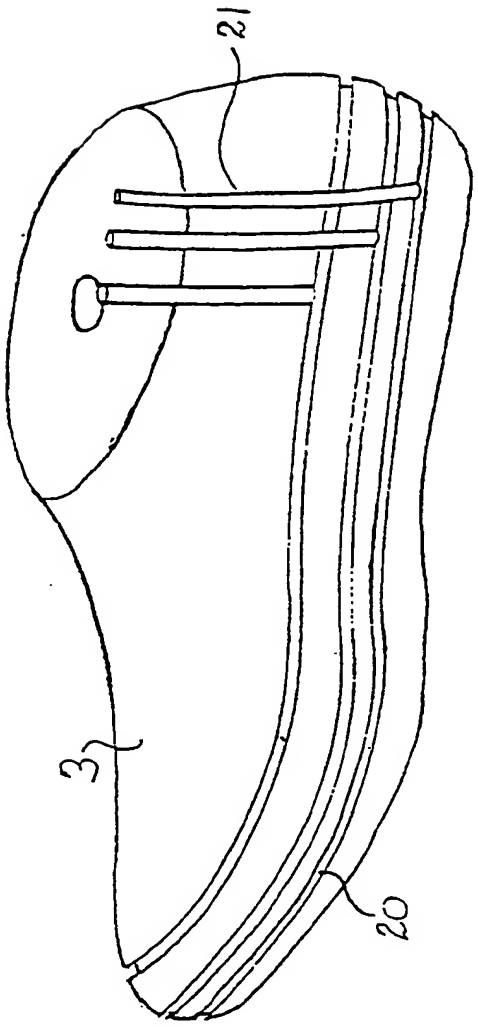


FIG 2

FIG 3



An artificial foot

This invention relates to an artificial foot intended, in particular to simulate a sweating human foot for testing footwear during the footwear design stage.

Sweating is a primary mechanism by which the human body regulates temperature, removes thermal energy, and disposes of residual body chemicals. There are two types of perspiration; vapour (insensible) and sweat (sensible). The quantity and chemical content of perspiration varies between different parts of the body and with different environmental conditions.

Perspiration vapour originates in the epidermal base of the skin and is produced by gaseous exchange in the epidermis due to thermal and pressure gradients. Insensible sweating rates for human feet given in the literature, range from 1.5 to 2.2 grams per hour for each foot.

Sensible sweat is produced from the sweat glands. There are two types of sweat glands (apocrine and eccrine), but most researchers agree that the human foot only contains eccrine glands. Sensible sweating rates for human feet, given in the literature, range from 1.5 to 25 grams per hour for each foot.

Because foot sweating can cause discomfort, there is considerable interest in studying ways to control sweating and in comparing the sweat management characteristics of different types of footwear and socks. For example, numerous studies aimed at determining the relative absorbency and wicking effect of different sock materials have been performed. Many attempts to measure evaporation of moisture from shoes have also been conducted. Many of these experiments have been hampered by the fact that the sweating rate of the human foot cannot be accurately controlled.

Other investigators have attempted to simulate a sweating human foot which can be used for laboratory studies, by forming a synthetic membrane material (such as Gortex (R.TM.)) into the shape of a foot. A significant problem with this approach is that the synthetic membrane material will only pass water in the form of vapour and, as a result, a foot made of these materials is only capable of simulating insensible sweat.

In order for an artificial foot to duplicate as accurately as possible the characteristics of a human foot, it is also desirable for the artificial foot to be maintained at human body temperature. US-A-4,432,223 teaches that a prosthetic foot (of the type used by amputees) can be modified, by the implantation of heaters and sensors, and that a foot with such modifications can be maintained at temperatures which closely simulate that of a human foot. Heated artificial feet, prepared in this manner, have proved to be useful for measuring the thermal insulating capabilities of different types of footwear.

The present invention seeks to provide an artificial foot which is able to simulate human sweating.

According to the present invention there is provided an artificial foot for testing footwear and/or socks, comprising a body portion having an outer surface, conduit means opening into said outer surface for enabling water to be supplied to parts of said outer surface, and water absorbent material covering at least part of the said outer surface of the body portion and all parts where the conduit means open into the said outer surface.

Preferably the water absorbent material comprises an open-cell foam material. In this case, water passed through the conduit means saturates the foam covering and appears on the external surface of the foam material as discrete droplets of water. These droplets closely resemble the beads of sweat which form on a human foot as a result of

sensible perspiration.

Preferably the conduit means comprise surface channels formed in the said outer surface and tubular passages communicating with the surface channels. The tubular passages are conveniently arranged in surface channels of the body portion, but may, instead, be arranged internally within the body portion. It will be realised, however, that the conduit means may take other forms. For example the conduit means may comprise a number of tubular passages formed in the body portion and extending directly to the said outer surface, e.g. from one or more internal chamber supplied directly with water.

The artificial foot may also include heating means to heat and maintain the artificial foot at a desired temperature in a relatively wide temperature range, e.g. from 15°C to 42°C, including typical human body temperatures. In this case the water produced at the external surface of the open-cell foam or other water absorbent material closely resembles insensible perspiration. Accordingly, both sensible and insensible perspiration can be simulated. To enable effective temperature control, the artificial foot is provided with temperature sensors and control means controlling the heating means in dependence on the sensed foot temperature.

The external shape of the artificial foot suitably resembles that of a human foot and can be used to test socks and/or footwear, e.g. shoes or boots, in conditions likely to be encountered during normal usage of the footwear and/or socks.

Means may be provided for controlling the rate of supply of water to the outer surface of the body portion and thereby controlling the "sweating" rate of the artificial foot.

An embodiment of the invention will now be described,

by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view of an artificial foot according to the invention showing a body portion and a covering portion covering the body portion;

Figure 2 is a view from below of a body portion of the artificial foot shown in Figure 1 with a sole part removed therefrom; and

Figure 3 is a schematic perspective view of the body portion of the artificial foot shown in Figure 1.

Figure 1 shows an artificial foot according to the invention and generally designated by the reference numeral 1. The artificial foot 1 is similar in certain respects to a standard SACH (solid ankle cushion heel) prosthetic foot of the type shown in Figure 3 of US-A-4432223 but has been modified in a number of respects. In particular, the artificial foot 1 has a body portion comprising a wooden core 2, a surrounding toe part 3 suitably made of a "hard" moulded rubber material, a heel part 4 suitably made of wood, plastics material or a "hard" rubber material, and a sole portion 5 made of a "softer" moulded rubber material. Elimination of the low density heel part of the artificial foot shown in US-A-4432223 makes the overall density of the foot more uniform and allows better temperature control of the artificial foot. Covering the body portion there is an open-cell foam covering 6. A through hole 18 is provided to attach the foot 1 to a testing apparatus (not shown).

In the lower surface of the toe part 3 there is embedded an electrical toe heating wire 7 (see Figure 2) and a toe temperature sensor 8. In the lower surface of the heel part 4 there is embedded an electrical heel heating wire 9 and a heel temperature sensor 10. Holes 12 are formed in the toe and heel parts 3 and 4 through which heater and sensor wires pass. These wires 7 and 9, sensors

8 and 10 and holes 12 are not shown in Figure 1. Although the wires 7 and 9 and sensors 8 and 10 could merely be sandwiched between the toe and heel parts 3 and 4 and the sole part 5, it is preferred to locate the wires 7,9 and sensors 8,10 in grooves formed in the under sides of the toe and heel parts and to encapsulate them in suitable flexible material, such as room temperature vulcanized silicone rubber. The sole part 5 is then adhered in position using suitable adhesive material so as to cover the heating wires and sensors.

Although the use of two heating wires 7 and 9 and two temperature sensors 8 and 10 have been described, it will be appreciated that any convenient number could be provided, the more such heating wires and sensors enabling more precise temperature control of the artificial foot.

Although not shown in Figure 1, a series of channels 20 (see Figure 3) are machined in the outer surface of the body portion of the artificial foot. Channels in different areas of the foot are totally separated from, and do not interconnect with, channels in other areas of the foot. By configuring the channels 20 in this manner, the rate of sweating in different areas of the foot can be separately controlled. Tubes 21 of plastics or other suitable material are located in grooves (not shown) in the surface of the body portion and are encapsulated in suitable flexible resin material. Each tube 21 connects a different channel 20 or series of connected channels 20 to the top (ankle) surface of the foot 1.

The covering 6 comprises sections of open-cell sheeting cut to fit the contours of the artificial foot. Conveniently one eighth inch thick natural sponge rubber sheeting with a 55-65 durometer hardness and a compression (at 25% deflection) of 10-16 psi has been found to work very well, but other suitable materials may also be used. The individual sheets are securely cemented to the outer surface of the body portion using cyanoacrylate adhesive or other

suitable material. The seams between the separate sections of the rubber sheeting are similarly cemented to one another using a suitable adhesive. The covering 6 is shown covering the entire "working surface" of the body portion of the foot 1. Although this is the preferred design, it is only essential to cover regions of the body portion where water is supplied to the outer surface of the body portion.

In use water, to simulate sweat, is introduced into the artificial foot by means of the tubes 21 which are connected to the channels 20. Water is supplied to the tubes by gravity, or by a mechanical pump (not shown), such as a syringe pump or peristaltic pump. The rate of sweating is controlled by regulating the flow of water to the tubes, e.g. by the use of flow meters or by controlling the speed of the pump. The water flows into the channels and wets the open-cell covering 6. The water appears on the outside of the covering 6 in the form of water droplets similar to sensible perspiration. By heating the artificial foot, water vapour can be generated which simulates insensible perspiration.

The artificial foot 1 described herein provides shoe manufacturers with the capability of testing new and existing designs of shoe for their performance in the area of sweat management. The artificial foot is able to flex in the manner of a human foot. The artificial foot is heated via two independent heating zones which can simulate body (surface) temperatures from 15°C to 45°C. The foot 1 is covered in a high density foam which, when the correct water delivery system is used, is able to sweat in separate, e.g. four separate, zones at rates from 1.5 grams/hour to 25+ grams/hour.

The temperature on the foot 1 can be measured at different surface positions and from a static thermocouple to give the hottest core temperature. When the foot 1 is in situ in a shoe being tested, the relative humidity of the microclimate of the toe or instep area can be measured.

A primary measurement used to performance rate a shoe on test is the weight of the shoe, sock and insole before and after the test and the in-test monitoring of the whole foot assembly and sweat system for weight.

During a test, the foot is suitably sealed in an environmental chamber, e.g. of the type described in our co-pending UK patent application filed on the same day as the present application, for the test duration. The conditions in the chamber can be controlled from 5% to 95% relative humidity and from 10°C to 50°C. The air flow over the shoe (i.e. through the chamber test section) can be set from 1-15mph and a pulsing air pump used to simulate the pumping action caused during walking from speeds of 0.1-10mph walking speed.

CLAIMS

1. An artificial foot for testing footwear and/or socks, comprising a body portion having an outer surface, conduit means opening into said outer surface for enabling water to be supplied to parts of said outer surface, and water absorbent material covering at least part of the said outer surface of the body portion and all parts where the conduit means open into the said outer surface.

2. An artificial foot according to claim 1, in which the water absorbent material comprises an open-cell foam material.

3. An artificial foot according to claim 1 or 2, in which the conduit means comprise surface channels formed in the said outer surface and tubular passages communicating with the surface channels.

4. An artificial foot according to claim 3, in which the tubular passages are arranged in surface channels of the body portion.

5. An artificial foot according to any of the preceding claims, including heating means to heat and maintain the artificial foot at a desired temperature in a relatively wide temperature range including typical human body temperatures.

6. An the artificial foot according to claim 5, provided with temperature sensors and control means controlling the heating means in dependence on the sensed foot temperature.

7. An artificial foot according to any of the preceding claims, having an external shape resembling that of a human foot.

8. An artificial foot according to any of the

preceding claims, including means for controlling the rate of supply of water via said conduit means to the outer surface of the body portion.

9. An artificial foot constructed and arranged substantially as herein described with reference to, and as illustrated in, Figures 1 to 3 of the accompanying drawings.

Patents Act 1977 10
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
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Relevant Technical fields

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(ii) Int Cl (Edition 5) G01M - 3/00 3/04 19/00
G01N - 15/08 17/00

Search Examiner
B F BAXTER

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASE: WPI

Date of Search
16 SEPTEMBER 1993

Documents considered relevant following a search in respect of claims 1-9

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

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Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

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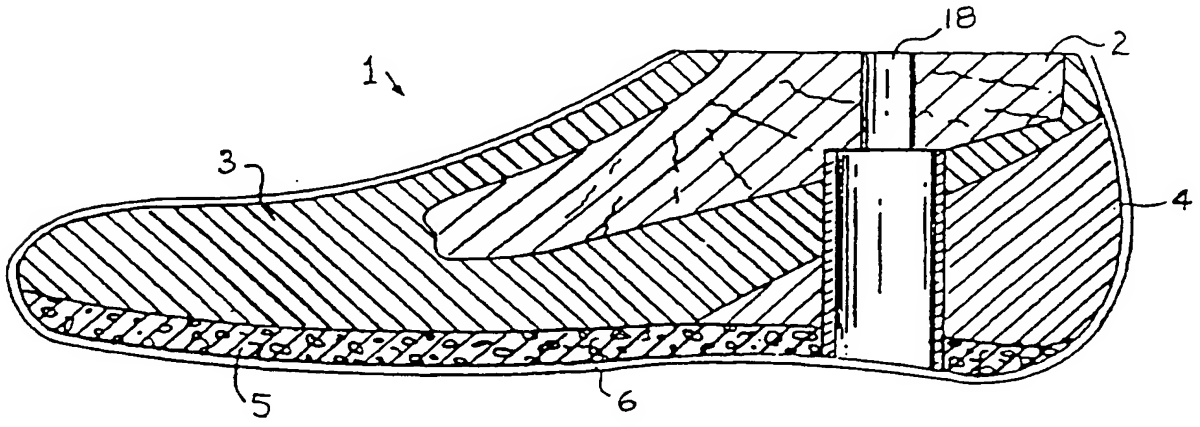

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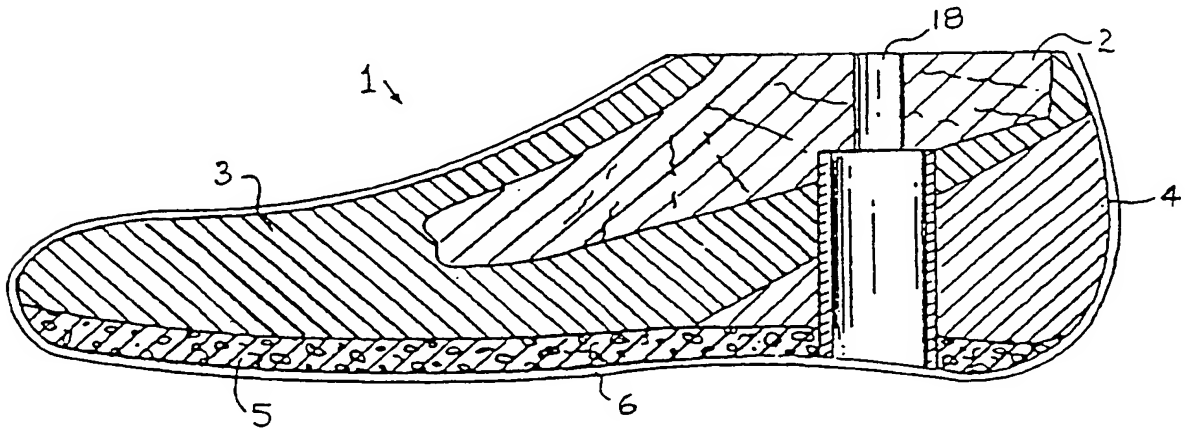

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This print incorporates corrections under Section 117(1)of the Patents Act 1977

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